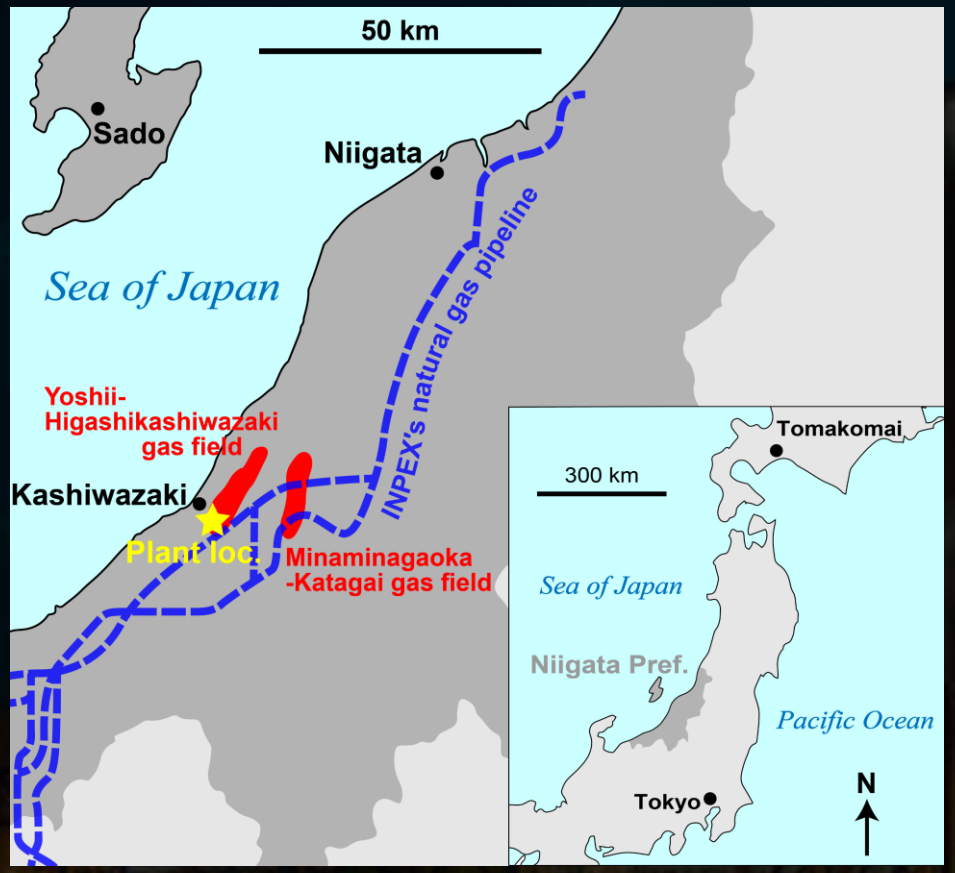
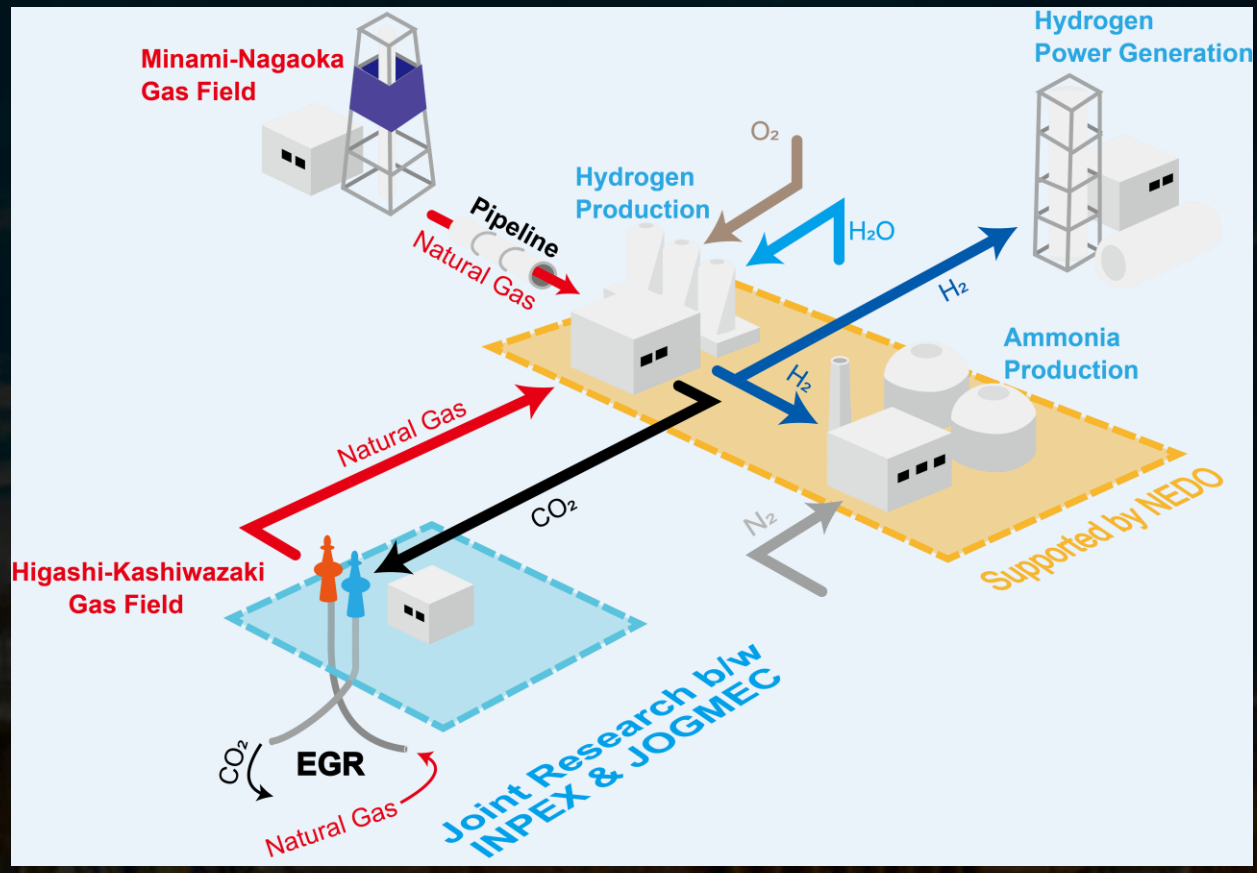
Clean Ammonia Demonstration Project in Niigata, Japan: Subsurface Perspective

JOGMEC
Yasushi SHIMANO
Japan Organization for Metals and Energy Security

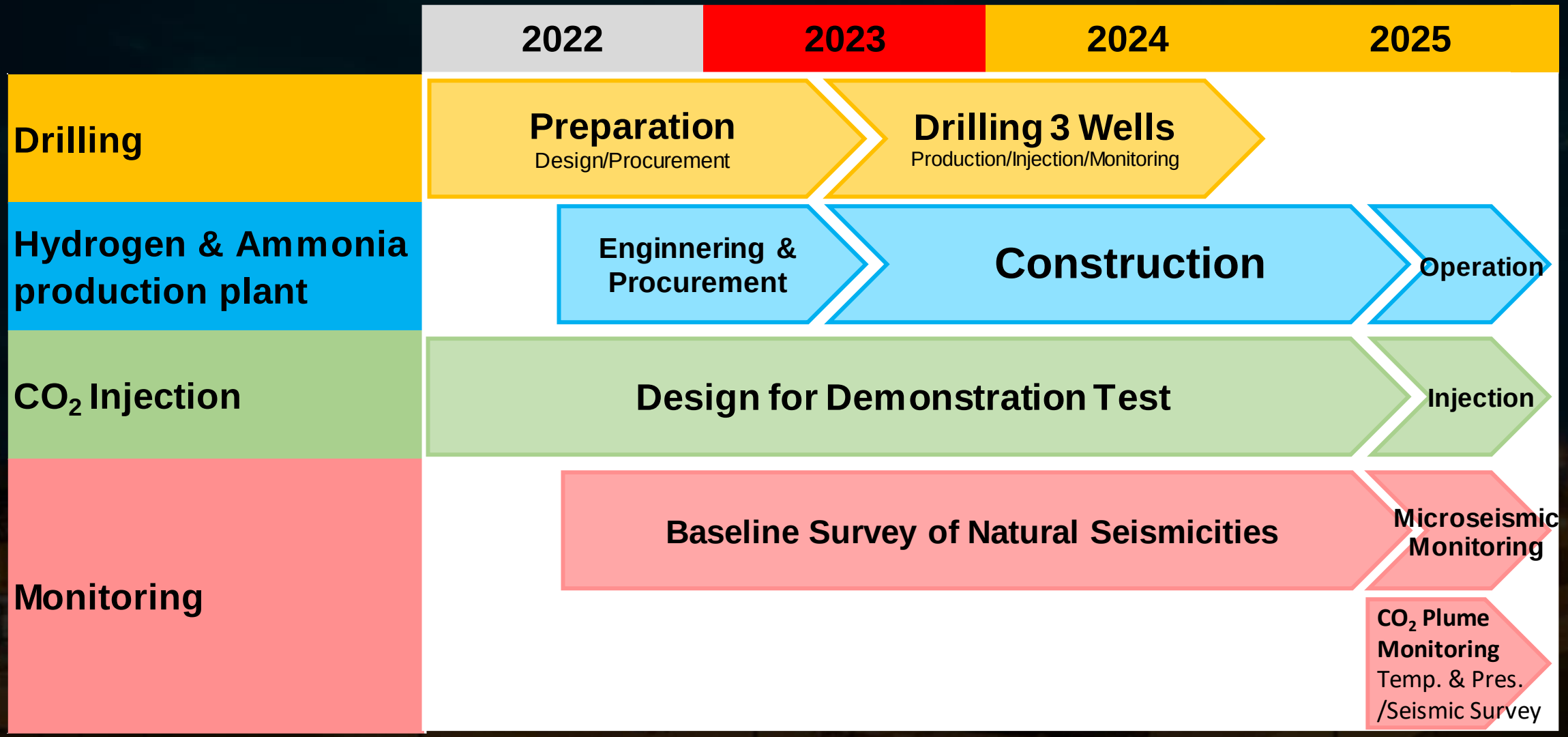
Project Overview



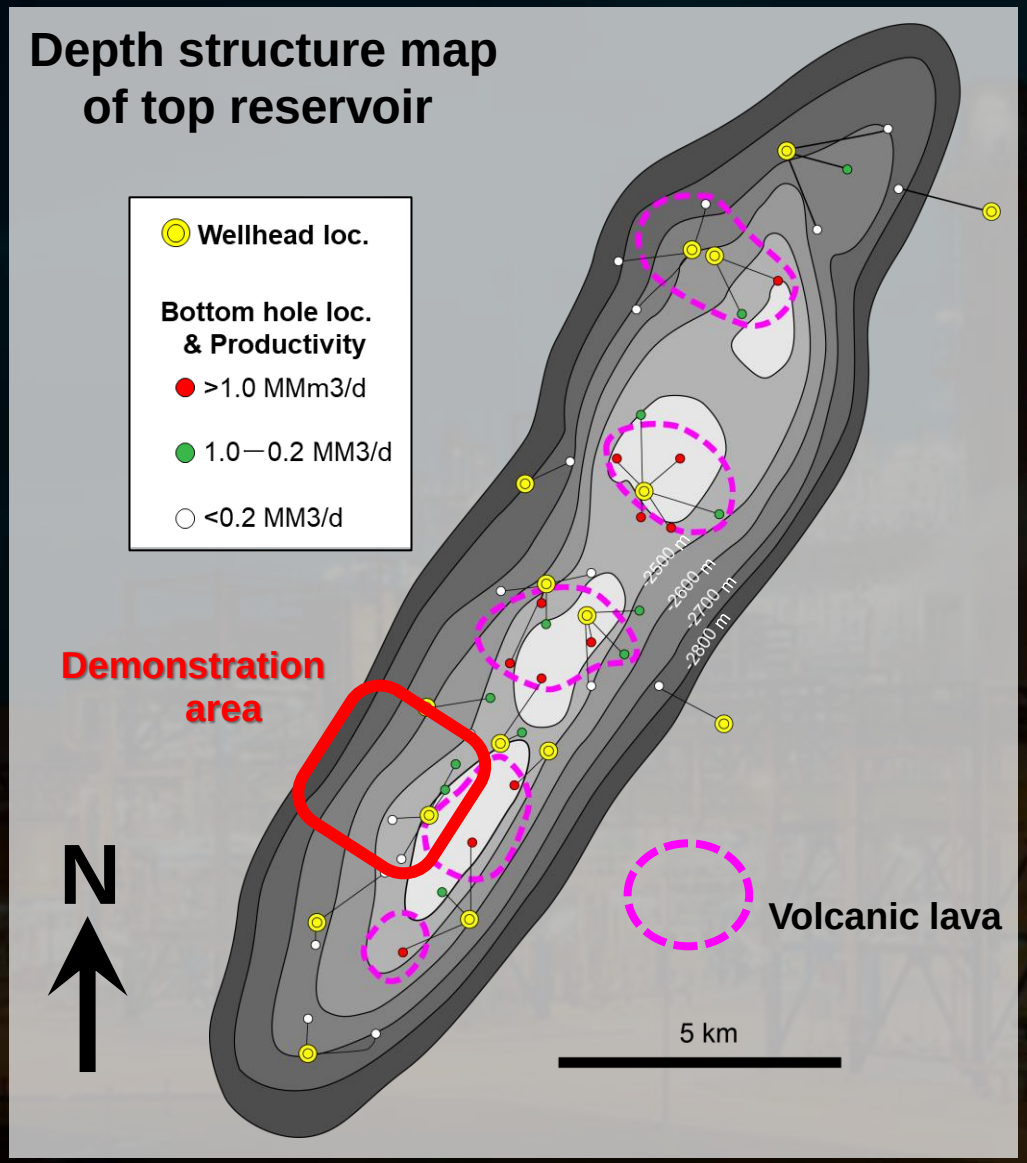


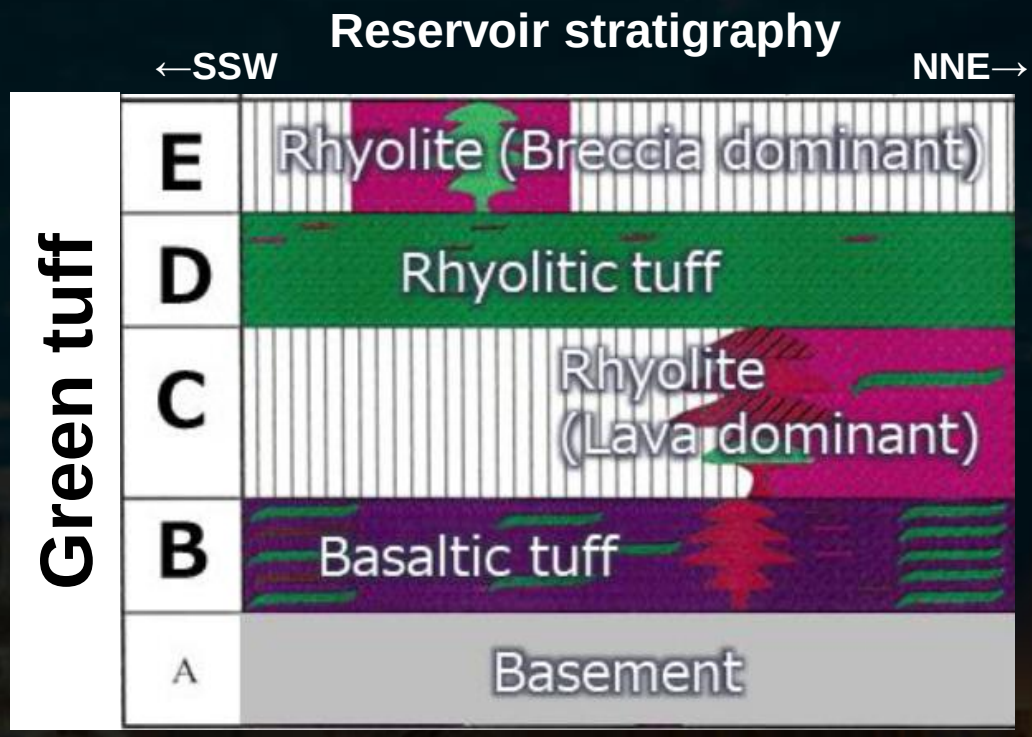
- INPEX, as an operator, plans to produce hydrogen and ammonia using natural gas produced from the Minami-Nagaoka gas field with the support of NEDO.
- INPEX and JOGMEC are conducting a joint research to inject associated CO_2 of hydrogen production into the depleted reservoir of the Higashi-Kashiwazaki gas field.

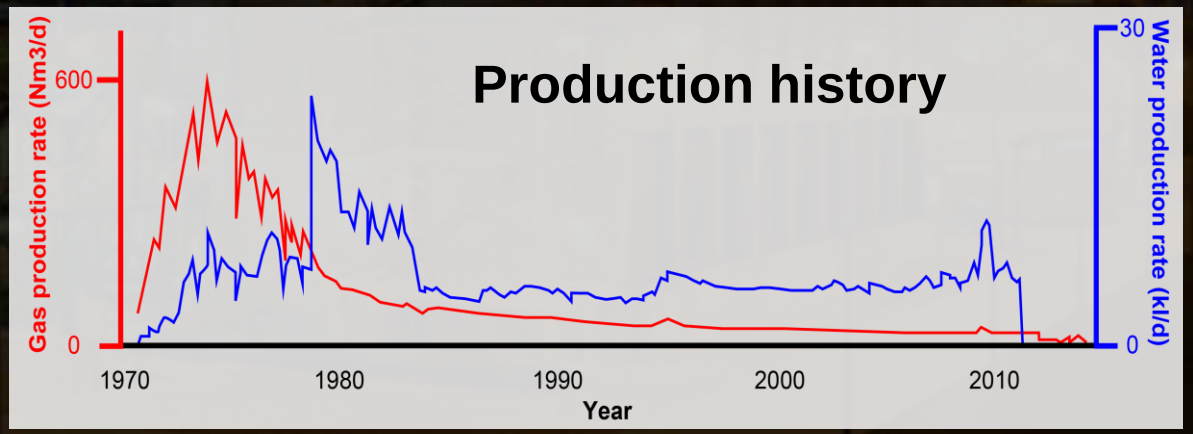
Project Schedule



Storage Reservoir Descriptions

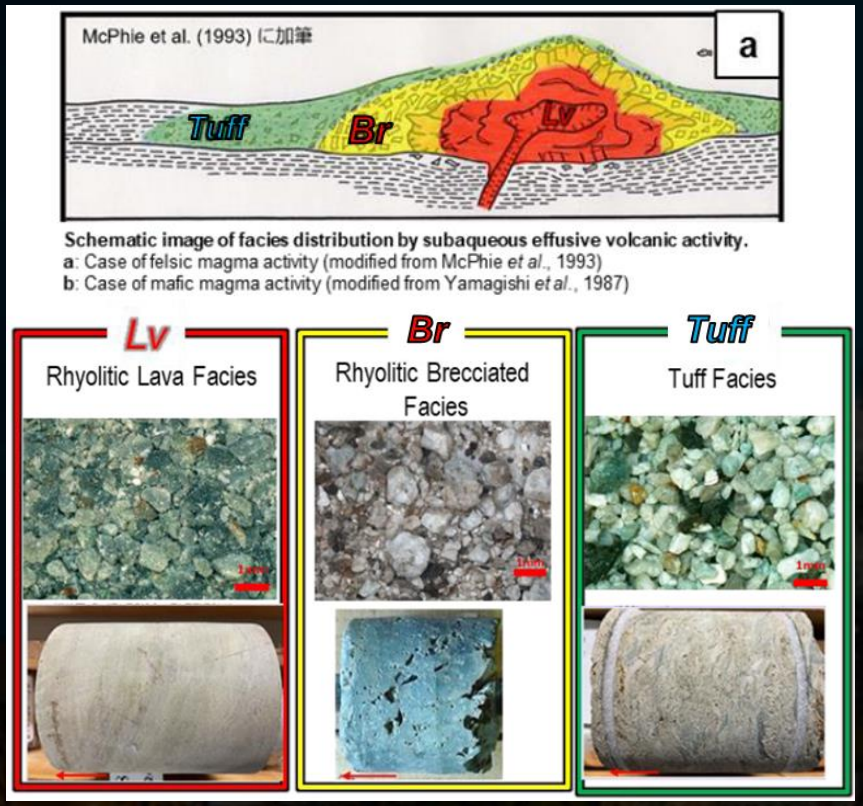




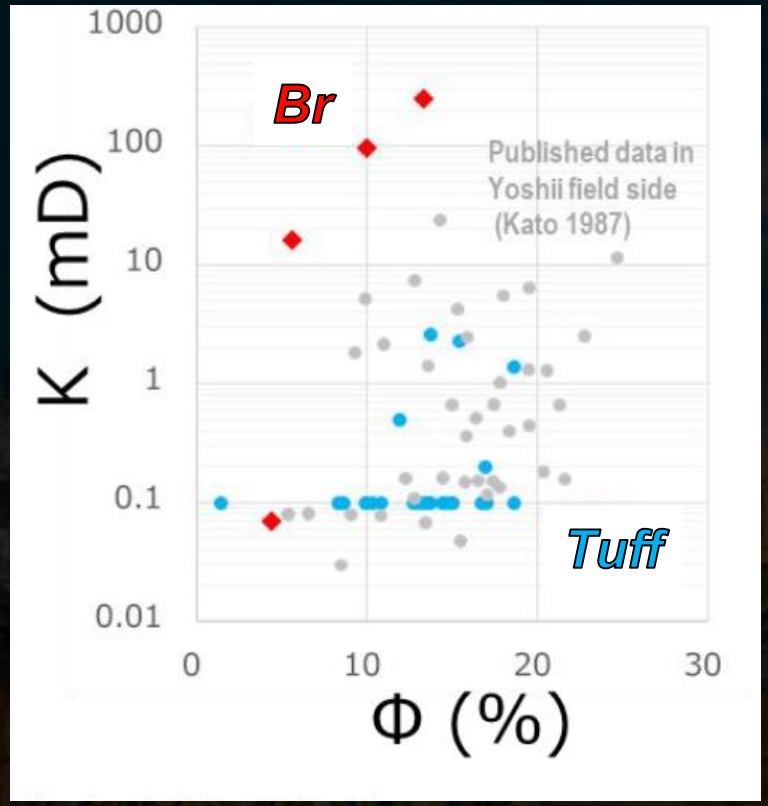


Technical Focus (1): Reservoir Characterization

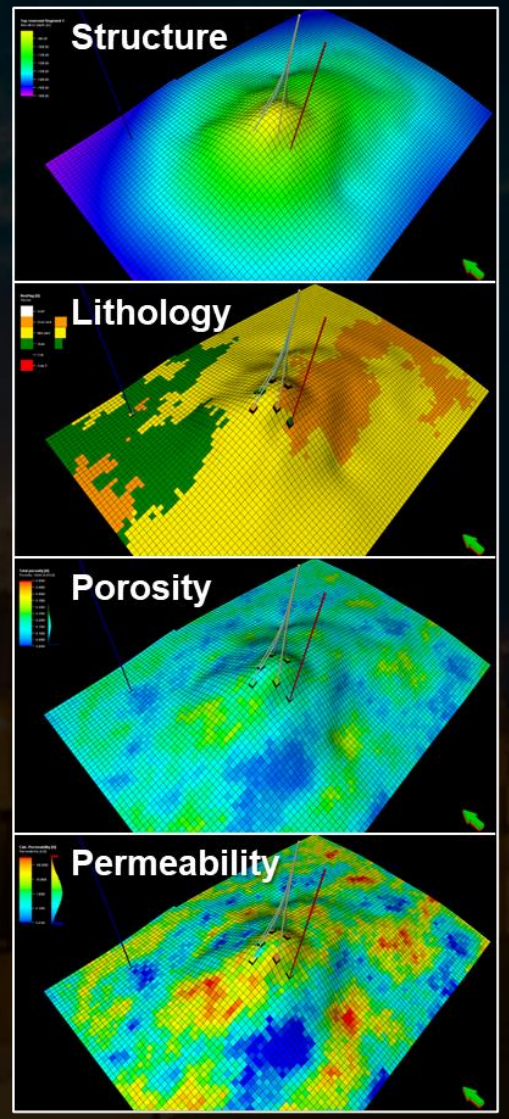
Geological concept & Observation



Laboratory analysis



Geological model

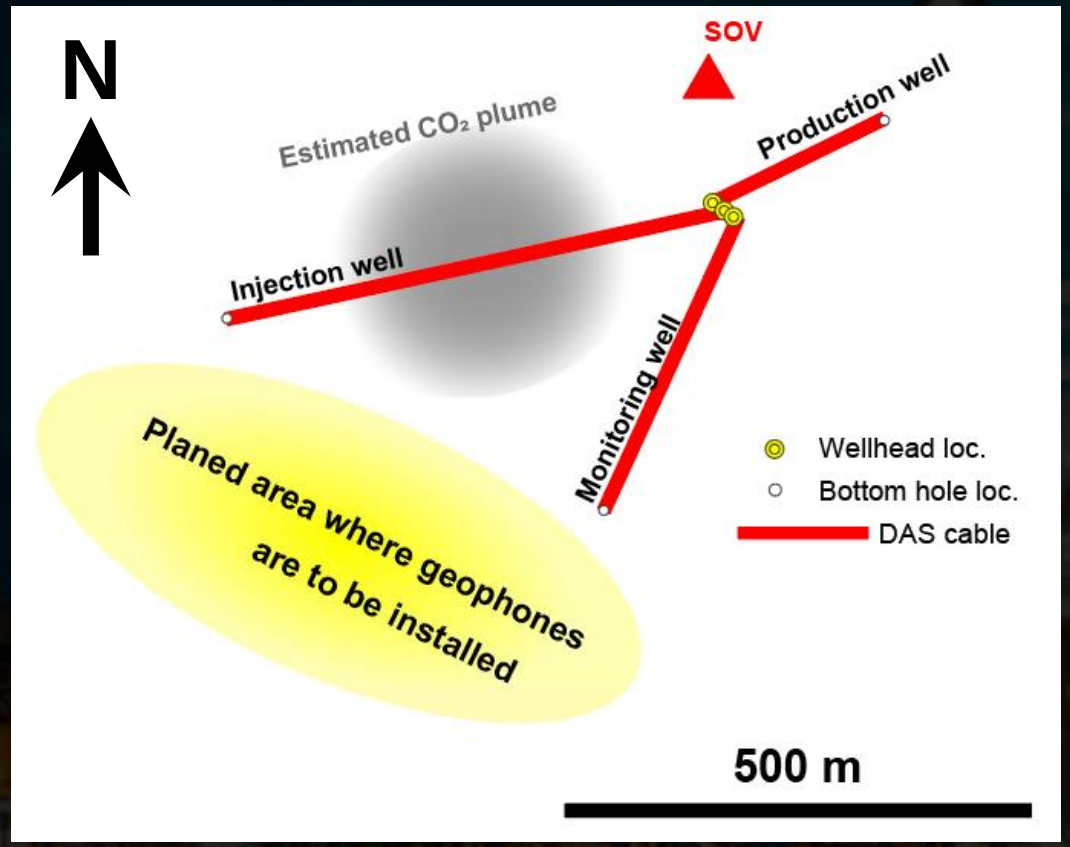


- The green tuff reservoir was characterized based on geological observations and laboratory analysis data.
- Available data were integrated to build a geological model.

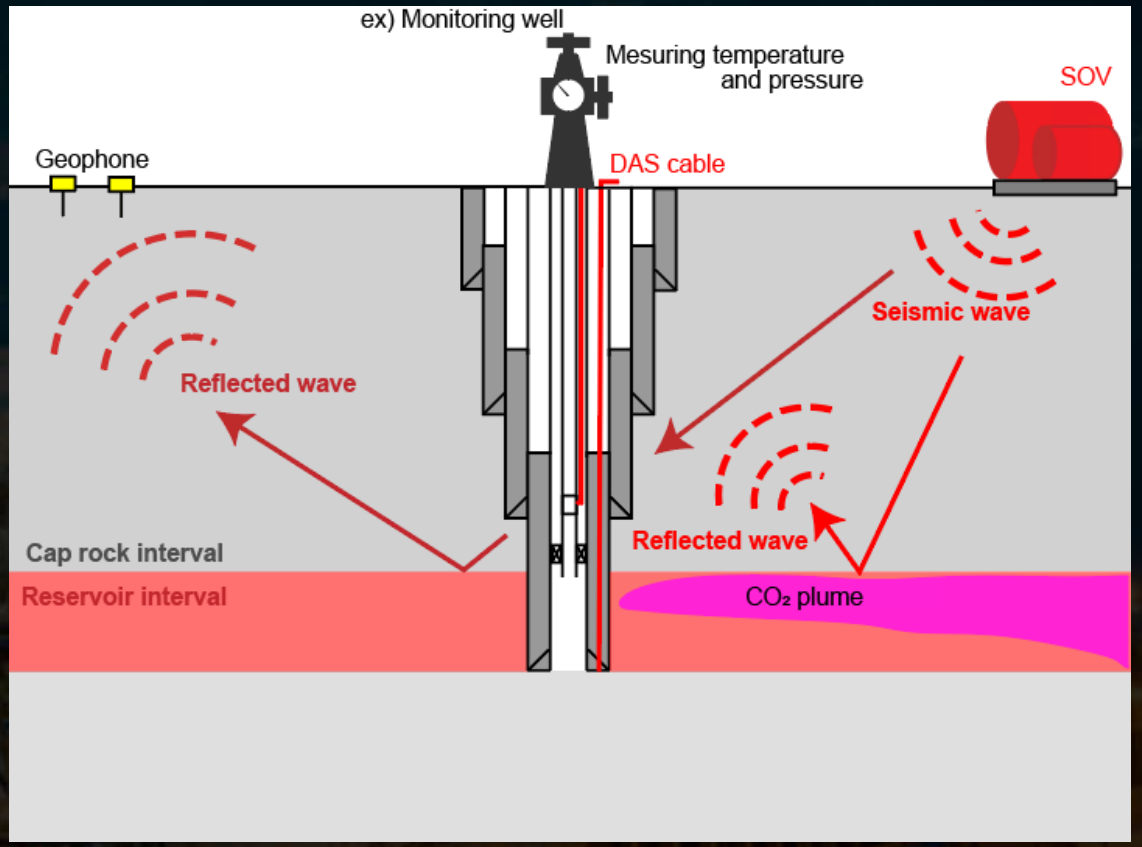
Conceptual

Technical Focus (2): Monitoring of CO_2 Plume Migration

Layout of the monitoring systems



Monitoring plans for CO_2 plume migration



- Gas production is still ongoing in the adjacent blocks.
- CO_2 plume behavior in the reservoir will be attempted to monitor using seismic survey methods.

Conclusions

- INPEX and JOGMEC are implementing a CCS/CCUS project at the Higashi-Kashiwazaki gas field that will contribute to clean hydrogen and ammonia production in Niigata, Japan.
- 3 wells will be drilled in 2023－2024, and hydrogen/ammonia production and CO_2 injection operations are planned to start from 2025.
- The reservoir, a volcanic rock formation called “Green Tuff”, has been characterized based on existing data, and a geological model has been built integrating available data.
- It is planned to monitor CO_2 plume migration using seismic survey methods in addition to reservoir temperature and pressure measurements at the wells.

Tsubame BHB

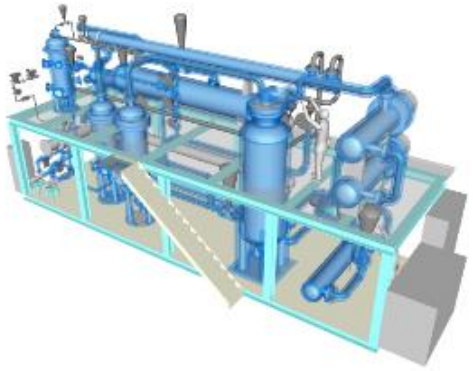
Confidential

Distributed Green Ammonia Production

by Low Temperature and Low Pressure Synthesis Tecnology

Tsubame BHB Co., Ltd.

June 2023



Tsubame BHB: Startup Company from the Tokyo Institute of Technology (Tokyo Tech)

- Established in April 2017.
- Financial Series C1 completed in 2022.

Establishment Background

Hosono Laboratory
(Tokyo Institute of Tech)

Innovative ammonia synthesis catalyst technology

Nature Chem. **2012**, *4*, 934-940

Tsubame BHB

Company Establishment

Ajinomoto Co., Inc.
(food and biotechnology)

Universal Materials Incubator Co., LTD.
(Venture Capital)

Company Overview

Name	Tsubame BHB Co., Ltd.
Main Address	4th Floor, Konwa Building, Tsukiji 1-12-22, Chuo-ku, Tokyo
R&D Center	4259 Nagatsuta-cho, Midori-ku, Yokohama City, Kanagawa Suzukakedai Campus, Tokyo Institute of Technology, J-3 Building, Room 1417
Kawasaki Branch	1-1 Suzuki-cho, Kawasaki-ku, Kawasaki City, Kanagawa Ajinomoto Co., Inc., Kawasaki Pilot Plant
Established	April 2017
Business Activities	R&D, production, sales and maintenance of Ammonia synthesis catalyst and On-site ammonia supply systems
Employees	60 (Incl. temporary employees)

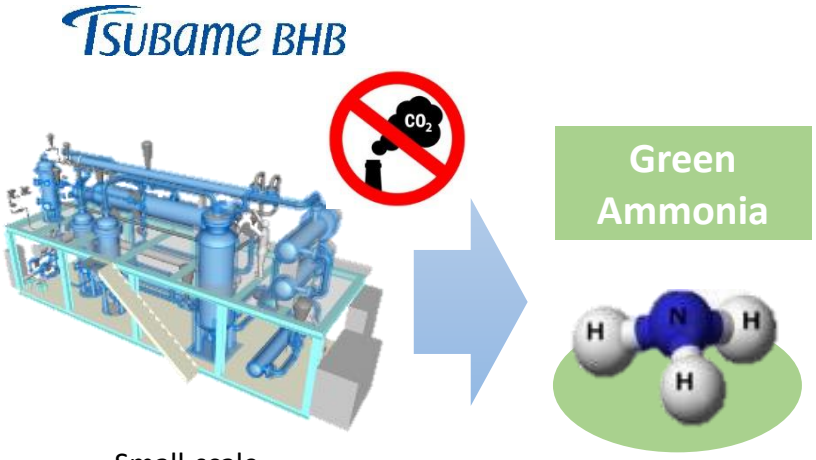
Main Stockholders

AJINOMOTO, idemitsu, MUFG 三菱UFJキャピタル, DJK, 三井住友信託銀行, SANKYU, Universal Materials Incubator Co.,Ltd., i-nest capital, みらい創造機構 MIRAI SOUZOU, DBJ, FUYO LEASE GROUP, INPEX, NYK LINE, MITSUBISHI CHEMICAL

Tsubame BHB provides a solution to de-carbonize the agricultural industry through modular system

1. **Replace conventional ammonia production with CO_2 emission to CO_2-free production**

2. **Reduce cost and stabilize ammonia supply-chain through distributed ammonia production**



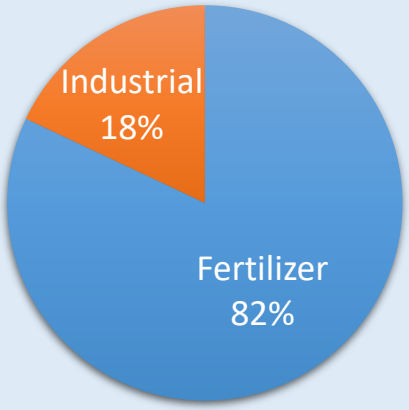
Small-scale Ammonia system without CO_2 emission

Tsubame provides a carbon-free solution for $90B market of Nitrogen Fertilizer

Ammonia

Existing Market: Total 180 million ton

Ammonia Application:



Emerging Market: **potentially new 100 Mton market in 2035**

Clean Fuel

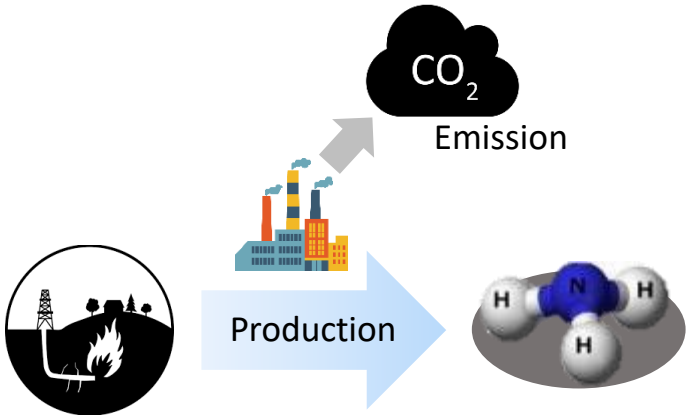
- Maritime Fuel
- fuel of coal power plant

Hydrogen Carrier

Ammonia production is emitting >1% of global CO_2 emission

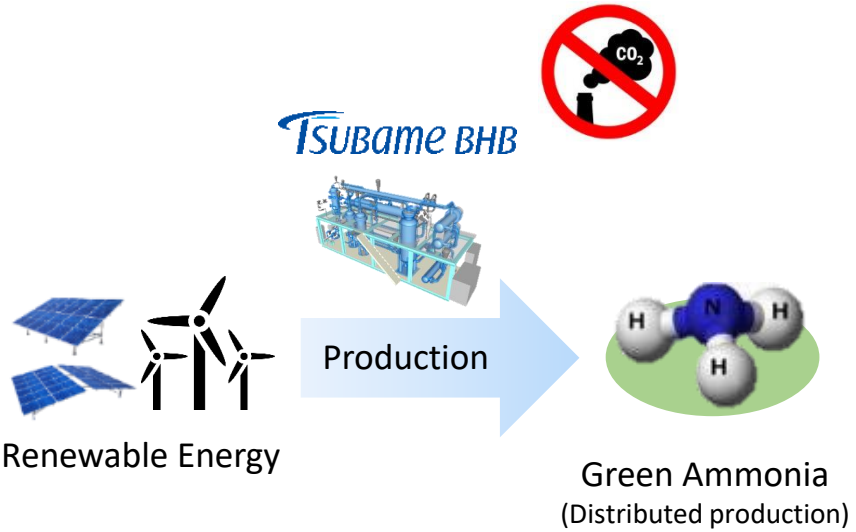
Current
Ammonia Production

>1% of CO_2 in global emission



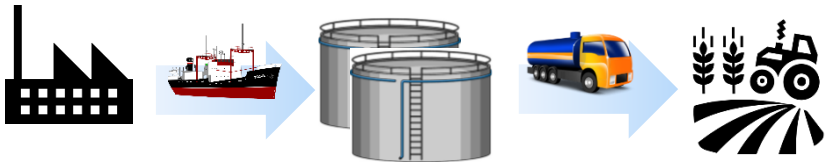
Green Ammonia Production
By Tsubame technology

No CO_2 Emission



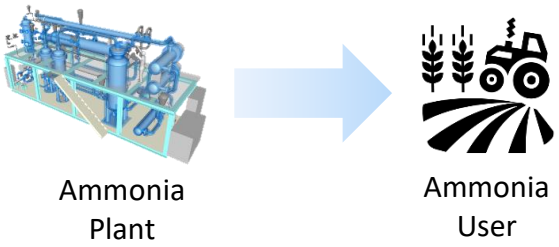
Supply-chain cost and Risk of supply chain interruption

Centralized production with supply chain



- ✕ Additional transportation and storage cost
- ✕ Additional risk of delivery interruption

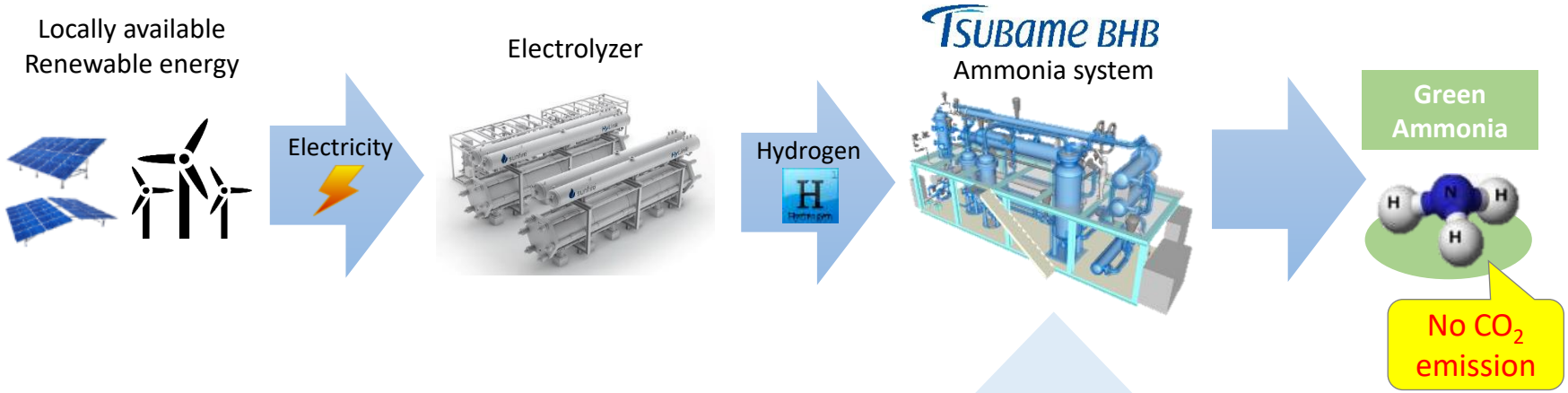
Onsite Ammonia Production



- ◯ Supply chain cost saving
- ◯ Stable ammonia supply

Green Ammonia Production by Small-scale production system

Semi-automated ammonia production system requires less operating labor, which enables user-friendly ammonia production.



Line-up of ammonia production system

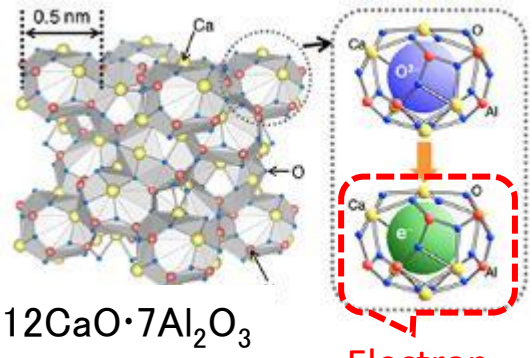
Type	Module			Plant
Name	TM-500	TM-3000	TM-5000	
Capacity	500 ton/yr	3,000 ton/yr	5,000 ton/yr	10,000 – 50,000 ton/yr
Size	17 yd x 23 yd	22 yd x 33 yd	27 yd x 37 yd	TBC
CAPEX (*1)	5-10 M USD	10-15 M USD	15-20 M USD	TBC
CO2 avoidance (*2)	800 ton-CO_2/year	5000 ton-CO_2/year	8000 ton-CO_2/year	16k – 80k ton-CO_2/year

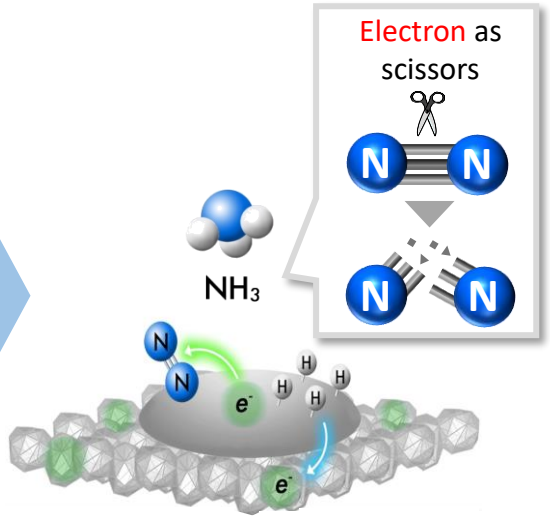
(*1: CAPEX is for reference purpose only)
(*2: comparison with natural gas based ammonia production)

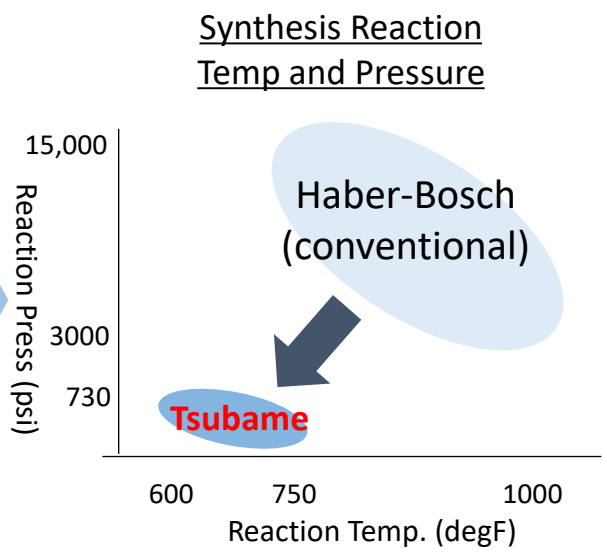
Tsubame's Electride Catalyst enables Low Temp. and Pressure Ammonia Synthesis

Our electride catalyst, developed by Tokyo Institute of Technology, creates an advantage on small-scale ammonia production compared to conventional Haber-Bosch process

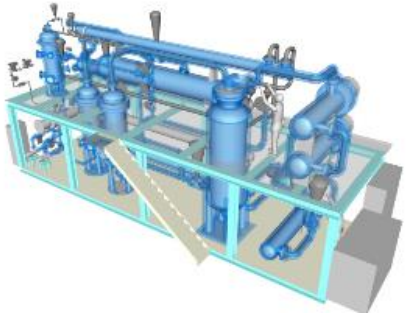
Unique Electride catalysts







Advantage on Small Scale production



Ready for deployment of commercial plant

Engineering and Procurement of 1st commercial plant is on-going.
We are ready to deploy our system for customers.

Achievement / Milestone

2017 2018 2019 2020 2021 2022 2023 2024 2025

Catalyst

Catalyst Industrialization

- Scale-up of catalyst manufacturing
- Establishment of catalyst raw material supplier
- Improvement of catalyst performance

Pilot Plant

Construction

- Scale-up design

Pilot Plant launched

Pilot plant in operation

- Confirmed better catalyst activity than expected
- Built operation experience
- Demonstrated ammonia synthesis process

Commercial

Ready to commercialize

sales

1st Plant Order Received

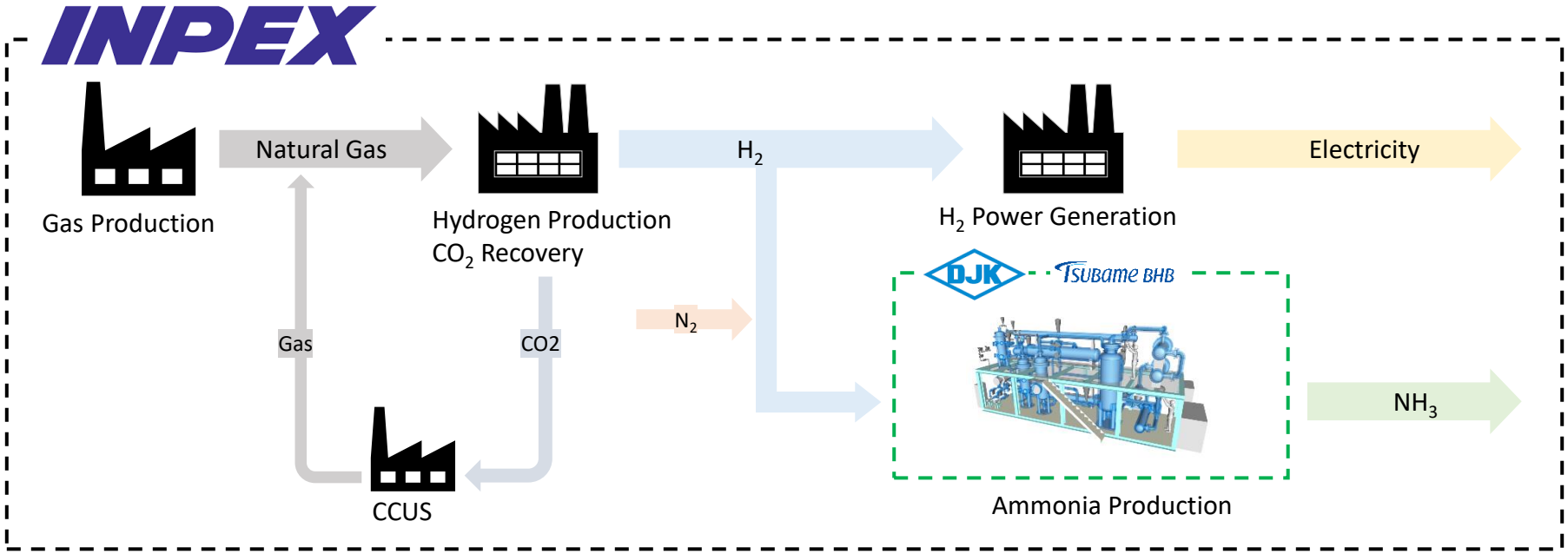
EPC

- On-going Engineering / Procurement / Construction
- Equipment is being manufactured by suppliers

Planned Start of Operation

1st Commercial Plant

PJ Owner :	INPEX Co.
PJ :	Kashiwazaki Clean Hydrogen/Ammonia Project
Plant Location :	Niigata, Japan
Contractor :	Daiichi Jitsugyo (DJK)
EPC Period :	Dec. 2022 ～ Aug. 2025, plan to start operation from Aug 2025
Capacity :	500 TPA (TM-500)

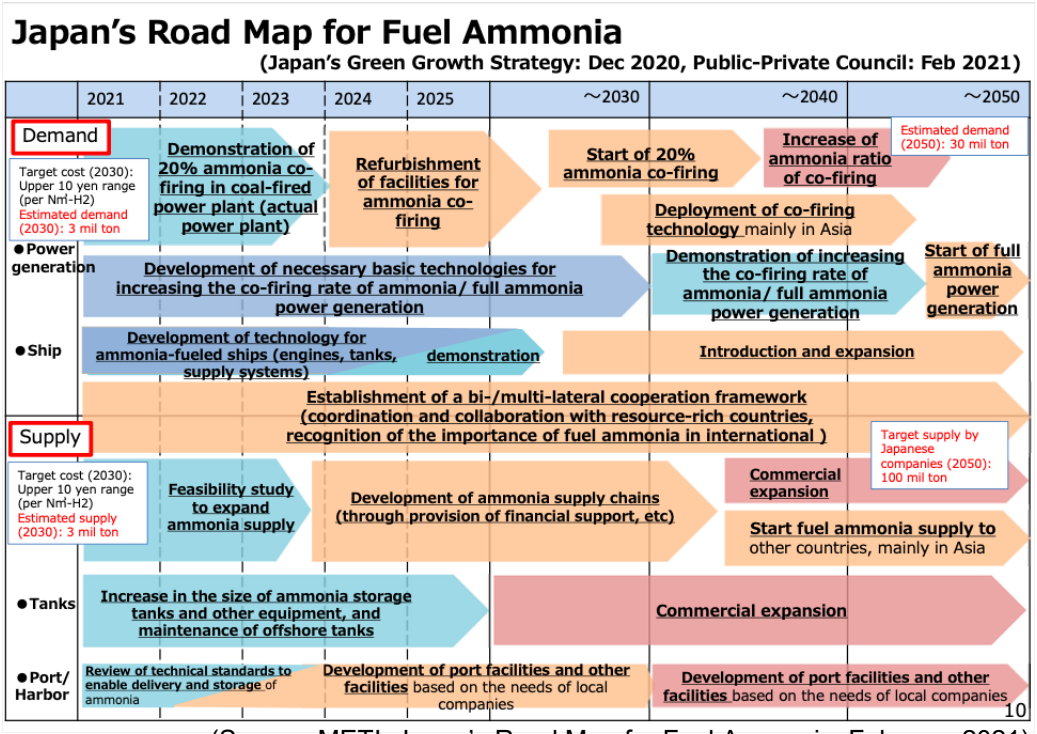


Appendix

Japan's Ammonia Co-firing in Coal Power Plant

Case	20% Co-firing	50% Co-firing	100% firing	(Reference) 20% co-firing in 1 plant
CO_2 Emission Reduction	40 M ton	100 M ton	200 M ton	1 M ton
Ammonia Demand	20 M ton	50 M ton	100 M ton	0.5 M ton

(Source: METI https://www.enecho.meti.go.jp/about/special/johoteikyo/ammonia_02.html)



(Source: METI, Japan's Road Map for Fuel Ammonia, February 2021)

US Market Strategy

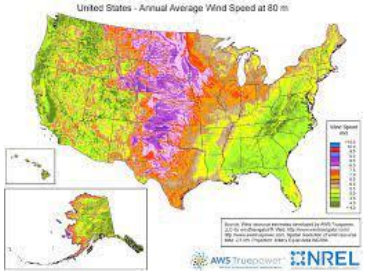
Market Environment in USA

Based on below environment, Tsubame is focusing market development of USA.
We are accelerating market development, and plan to assign representative in US from March.

1. Subsidy
   - IRA approved: subsidy on green-H_2 as 530 USD/ton-NH_3

2. Ammonia
   - Existing large market demand by Fertilizer
     Using anhydrous ammonia as direct fertilizer
   - Supply chain:
     - Inland transportation costs high
     - Safety concern on transportation

3. Renewable Energy
   - Competitive renewable energy cost for both solar and wind



Partner Candidate

We'll contact and talk potential collaboration with these companies.

NEXTera ENERGY
Renewable Energy Group
Green Mountain Energy
Clearway
tpi COMPOSITES
First Solar
TESLA ENERGY

- W.D. Service Co., Inc.
- SAE Manufacturing Specialties Corp
- Paul Akers, Inc.
- Ravago Chemicals North America
- DeLille
- Hydrite Chemical Co.
- Chemicals Direct USA
- Koch Fertilizer, LLC.
- C&E Services
- Southern Lonics, Inc.
- Terra Industries, Inc.
- U.S. Chemicals, LLC.
- Combustion Associates
- OxyChem
- Dakota Gasification Co.
- Simplot, J.R.,Co.
- Mil-Spec Industries
- Tessenderlo Kerley, Inc.
- Calamco
- Energys, USA Inc.

- Wilgrow Fertilizer
- Triad Nitrogen Inc
- Triad Chemical
- Agricultural cooperative

1 Renewable Energy Green H_2 Hub

2 Ammonia Production

3 Ammonia Distributor

4 Anhydrous Ammonia Agri Machinery

5 Farmer

CF
Mosaic
LSB INDUSTRIES
KOCH INDUSTRIES INC
Nutrien
Green Valley Chemical
YARA
COFFEYVILLE RESOURCES
DYNO Dyno Nobel
OCI IOWA FERTILIZER
BASF We create chemistry

Agriculture Cooperative

- CALAMCO
- CHS Inc, Minn
- Dairy Farmers of America, Mo
- Land 'Lakes Inc, Minn.
- GROWMARK Inc, Ill
- Ag Processing Inc. Neb
- California Dairies Inc. CA
- United Suppliers Inc. Iowa
- Northwest Dairy Association Wash
- Southern States Cooperative Inc. VA
- Foremost Farms Wis
- Prairie Farms Dairy Inc. Ill

Crops Company

Cargill Helping the world thrive
ADM
syngenta

others

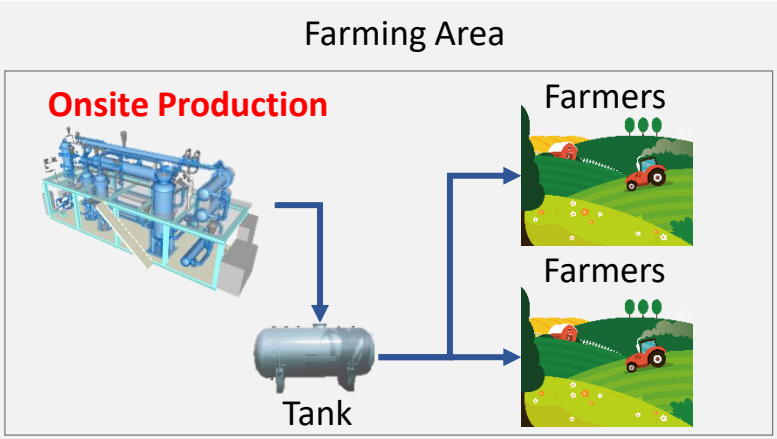
Our Solution : Small scale Onsite Ammonia Production

- Tsubame BHB offers Small sale Onsite ammonia production
- Our method enables customer's ammonia cost reduction by low pressure and temperature technology

Onsite Production

- Produce required volume at the next to consuming location
- Our Technology enables small scale ammonia plant

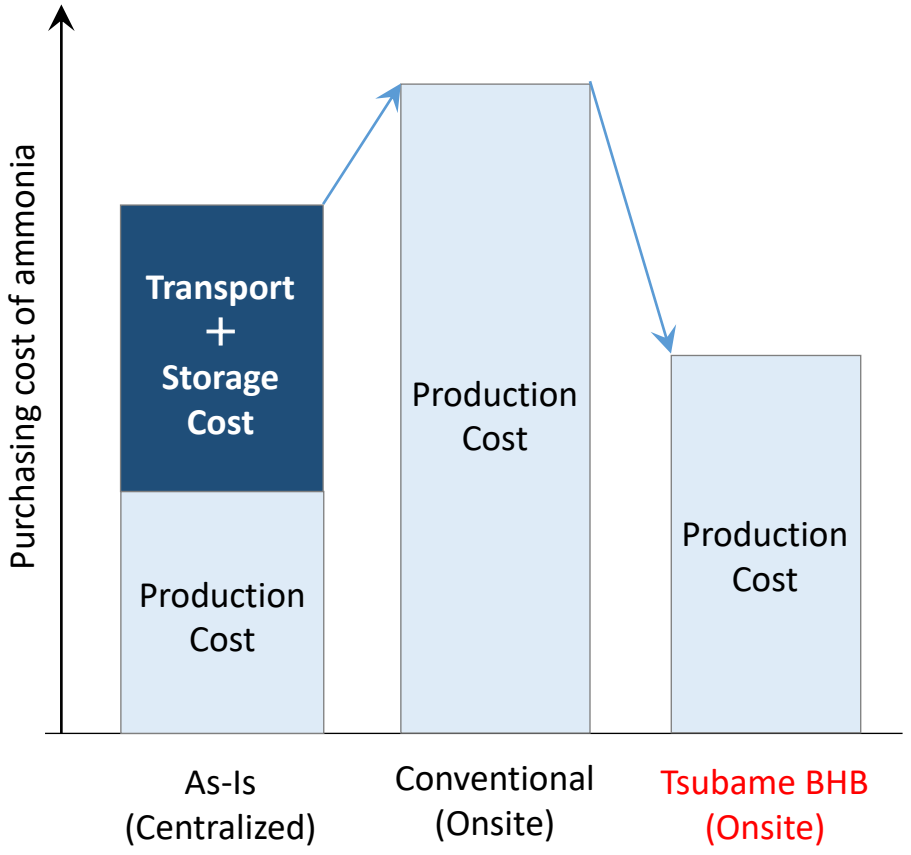
Example: Fertilizer application



Advantage

- No Transpiration and Storage cost
- Stable Supply

Cost Reduction from customer viewpoint



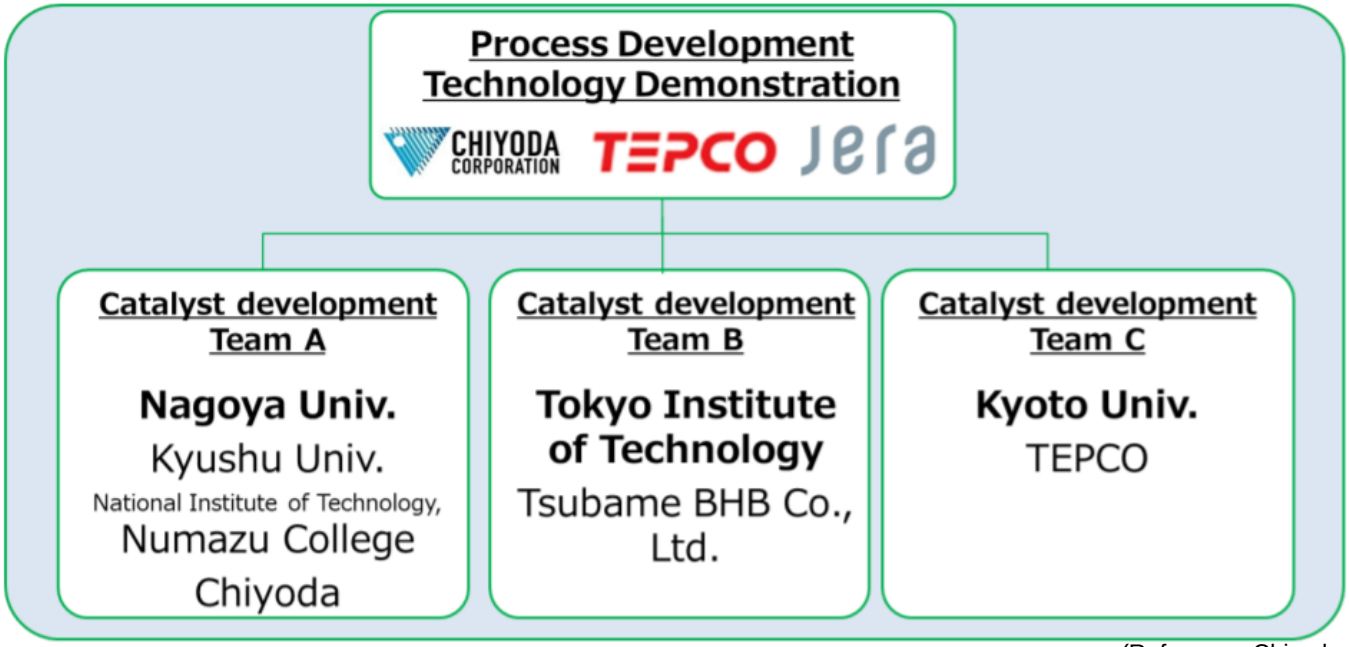
Development of New Generation catalyst for Large-scale Ammonia Plants

NEDO project for fuel ammonia was announced on Jan 2023.
Tsubame BHB and Tokyo Institute of Technology was selected as subcontractors of catalyst.

GI Fund Project by NEDO

- Project Period: 2021 to 2030
- Main Company: Chiyoda Corporation / TEPCO / JERA
- Objective: Develop Ammonia production technology for large scale plant
- Role of Tsubame BHB: Develop **non-precious metal catalyst** for large scale plant by 2024 with Tokyo Institute of Technology

R&D Organization



(Reference: Chiyoda Corporation Press Release)

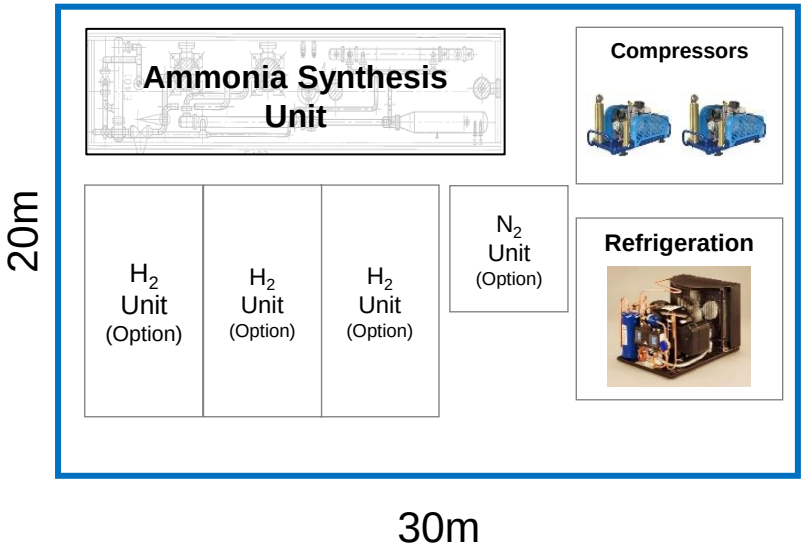
Business Model A: Module system sales

- Standardized Ammonia Module
- Optimized module provides short term delivery and competitive cost

Module Specification

Name	TM-500	TM-3000	TM-5000
Capacity	500 ton/year	3,000 ton/year	5,000 ton/year
Size	16 m x 21 m	20 m x 30 m	25 m x 35 m
Weight	x kg	x kg	x kg
Working hours	8,000 hours/year	8,000 hours/year	8,000 hours/year
Delivery	24 months	24 months	24 months
Remarks	• Auto-startup • Auto-shutdown	• Auto-startup • Auto-shutdown	• Auto-startup • Auto-shutdown

Module Design (3,000 ton/yr)



Ammonia Project Features

(Thursday 29 June, 3PM CET, online via Zoom Webinar)

Demonstrating CCS-based ammonia production in Japan

Yasushi Shimano
Deputy Director (Geologist) of Subsurface Division, Hydrogen and CCS Project Department, JOGMEC

Tomoyuki Koide
Deputy General Manager Marketing, Tsubame BHB

In conversation with:

Kevin Rouwenhorst
Technology Manager, AEA

AMMONIA ENERGY ASSOCIATION

AMMONIA ENERGY ASSOCIATION

Fifth Annual APAC conference on Ammonia Energy

AMMONIA ENERGY ASSOCIATION

Fifth Annual

APAC Conference

AMMONIA ENERGY APAC

Answering the call to action.

August 16-18, 2023

Newcastle, Australia

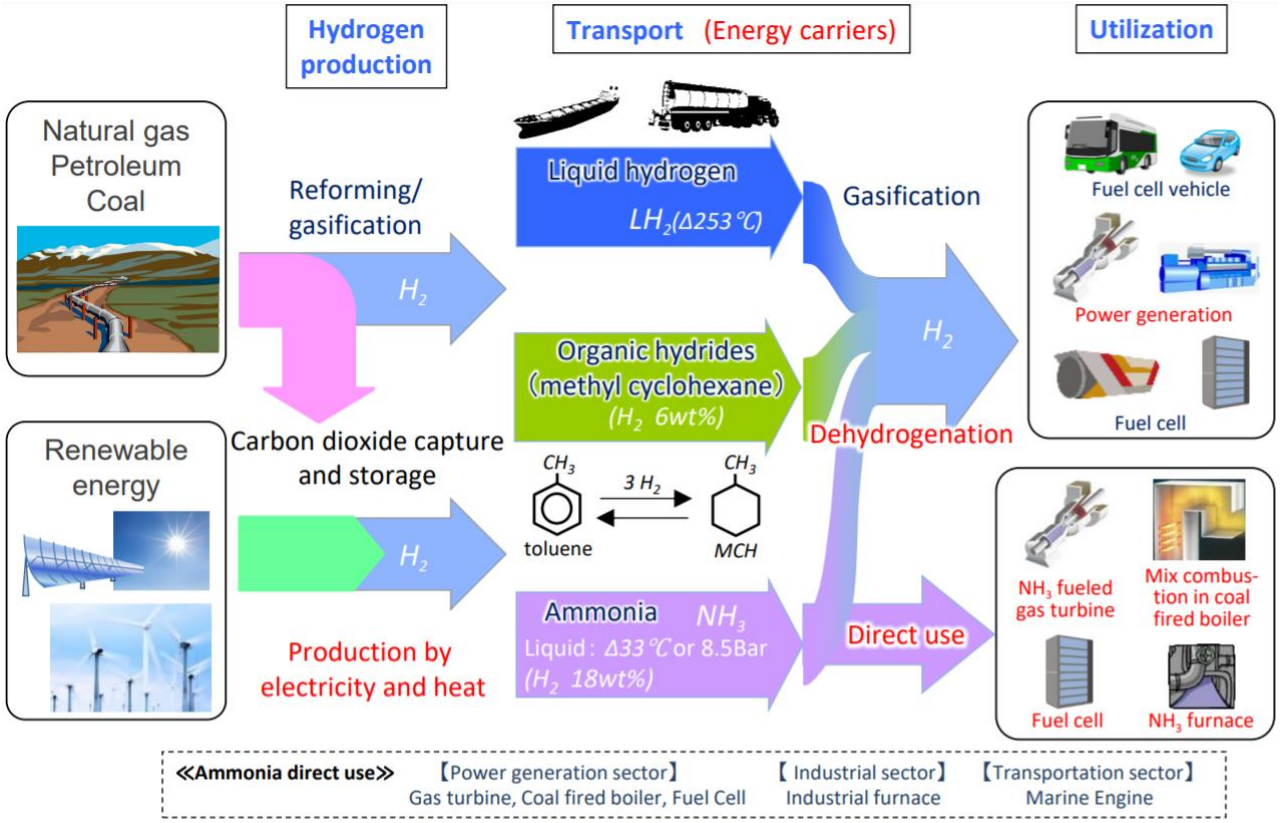
CSIRO Energy Centre, Mayfield West

Registration Open

Link: https://www.ammoniaenergy.org/2023-aea-apac-home/

Ammonia strategy

- Currently, Japan imports its energy as coal and LNG
- Japan was the first country with a clear vision for ammonia to decarbonize its energy imports within the **SIP energy carriers** programme

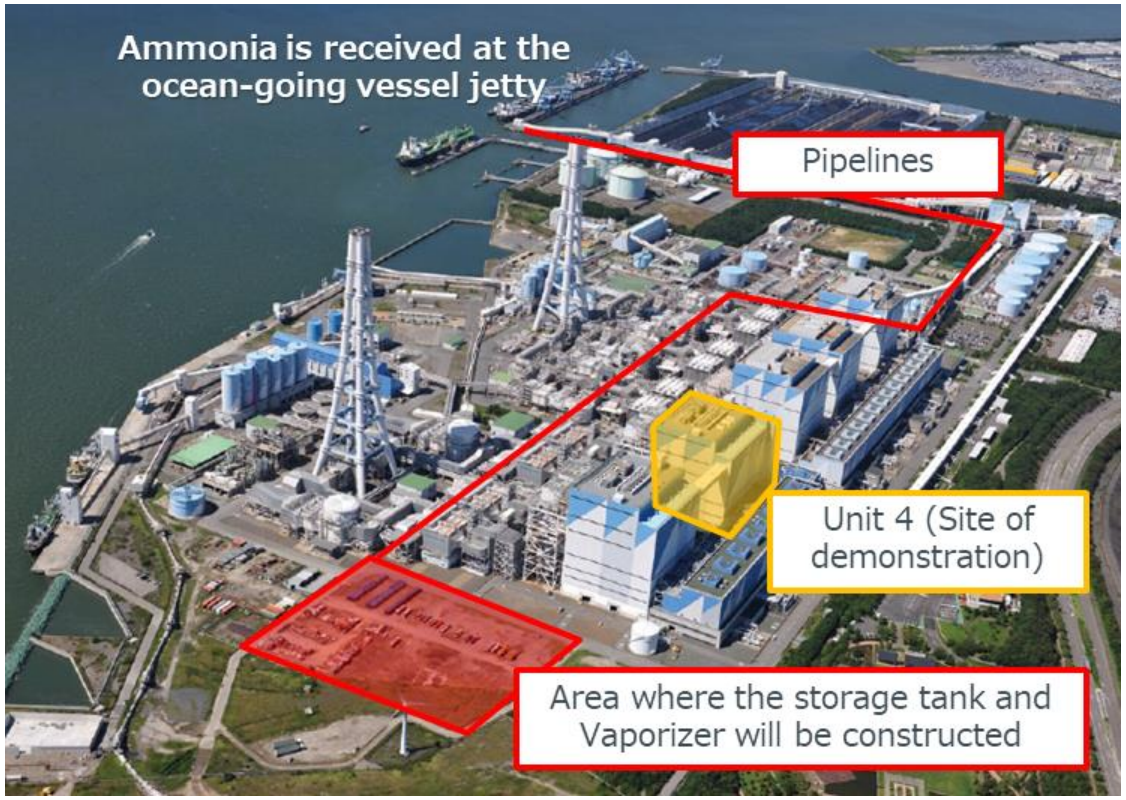


Link: https://www.ammoniaenergy.org/wp-content/uploads/2021/02/AEA-Imp-Con-01Nov18-Shigeru-Muraki-Keynote-Address.pdf

AMMONIA ENERGY ASSOCIATION

Ammonia for thermal power plants in Japan

- JERA aims to import low carbon ammonia to co-feed 20% ammonia at its coal-fired Hekinan Thermal Power Unit 4 in 2027, requiring 500 KTPA of ammonia

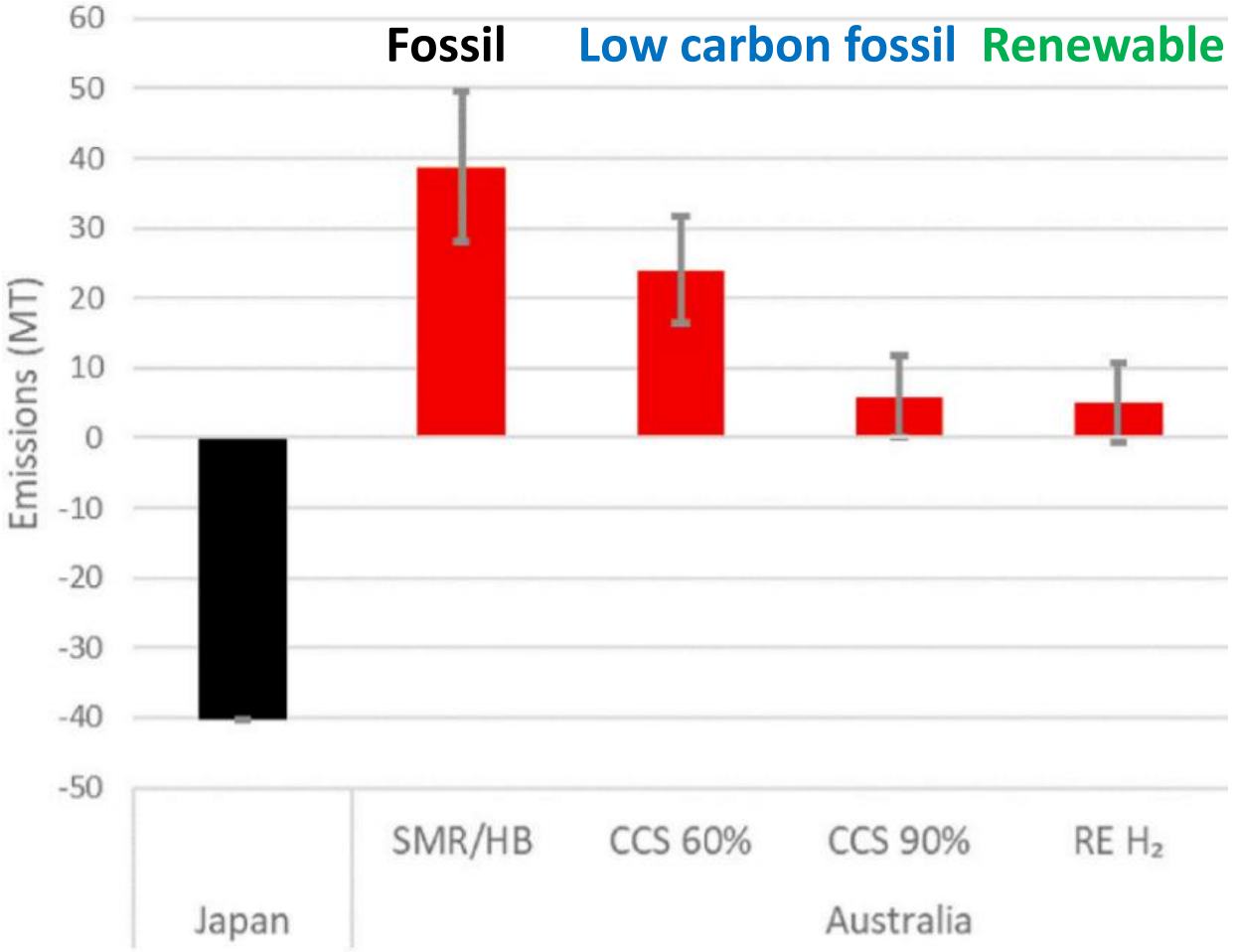


Link: https://www.jera.co.jp/en/news/information/20210524_677

AMMONIA ENERGY ASSOCIATION

Low carbon ammonia value chain

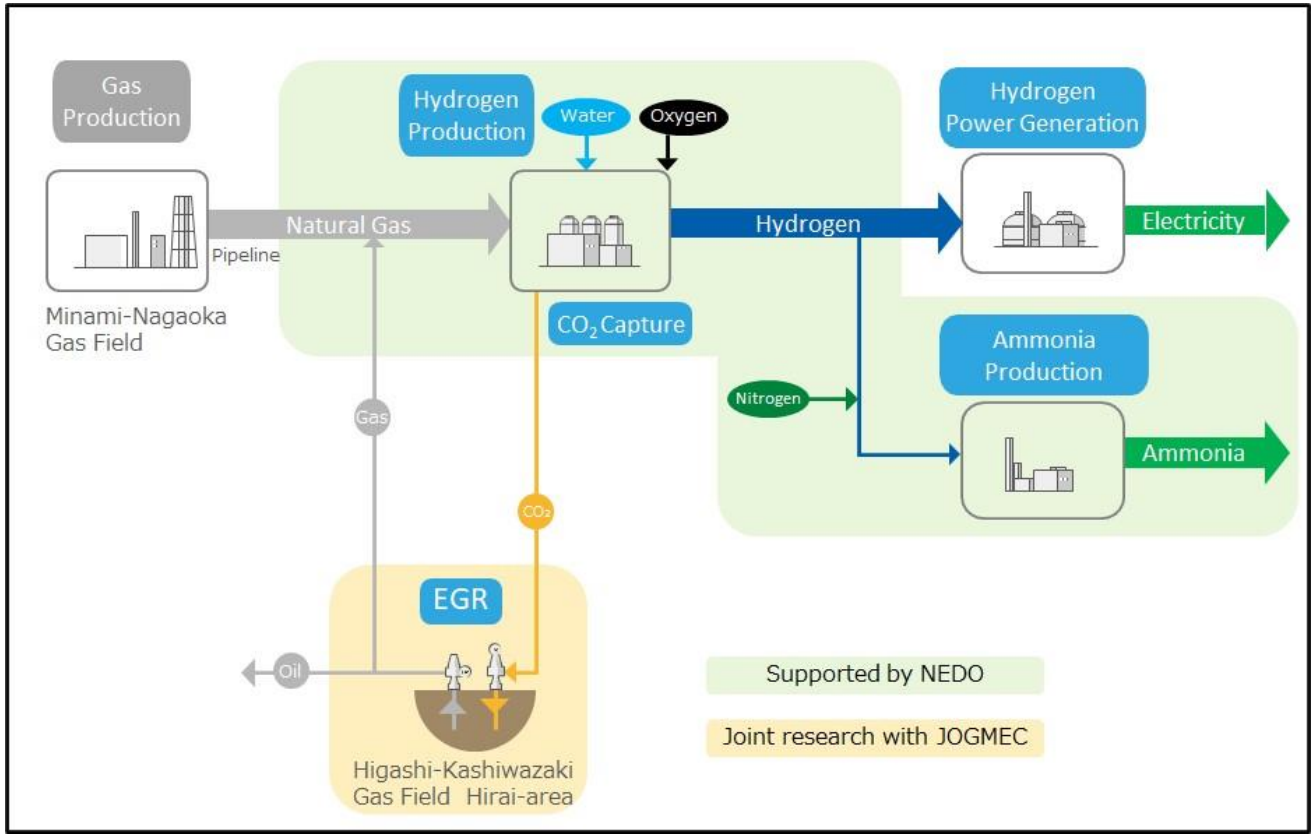
- **Australia-Japan case**: need low carbon ammonia for decarbonization versus fossil fuels
- **Assumption**: 20% co-firing of ammonia in all coal-fired power plants in Japan



Link: https://www.sciencedirect.com/science/article/abs/pii/S095965262104258X

Demonstrating CCS-based ammonia production in Japan

- INPEX-led project will demonstrate 500 tonnes low carbon ammonia production per annum (1.4 tonnes per day) in Niigata based on ATR-based hydrogen
- Operational from August 2025



Link: https://www.ammoniaenergy.org/articles/small-scale-ccs-ammonia-in-japan/

Ammonia Project Features

(Thursday 29 June, 3PM CET, online via Zoom Webinar)

Demonstrating CCS-based ammonia production in Japan

Yasushi Shimano
Deputy Director (Geologist) of Subsurface Division, Hydrogen and CCS Project Department, JOGMEC

Tomoyuki Koide
Deputy General Manager Marketing, Tsubame BHB

In conversation with:

Kevin Rouwenhorst
Technology Manager, AEA

AMMONIA ENERGY ASSOCIATION